Public Workshop
on
Residential Furnace and Boiler Venting

May 8, 2002

Introduction Outline

- Background
- Purpose
- Discussion Items
- Next steps

Background

Since FY'2001, DOE has pursued rulemaking activities to determine if updated standards for covered residential furnaces, boilers and mobile home furnaces are justified.

–June 19, 2001: notice announced public workshop and the availability of the framework document.

–July 17, 2001: "framework workshop" to explain and discuss the process, analysis, and issues involved in the rulemaking.

–During the framework workshop, several stakeholders expressed concerns regarding venting implications of increased minimum standards.

Venting Concerns

Several comments were raised in response to the framework document workshop, which expressed concerns about venting in mid-efficiency appliances.

"Economic venting options should be considered, which permit higher efficiency levels without concern for flue gas condensation, as well as appliance condensation."

Energy Kinetics

"…consider the effect of higher efficiencies on the equipment's venting capability."

National Propane Gas Association

"Increasing the AFUE level beyond 80% will create additional venting and corrosion durability problems, particularly in northern markets."

"Furnaces having an 81-82% ICS AFUE level (82-83% indoor AFUE) were widely available in the 1980's and experienced numerous venting and corrosion problems."

Carrier Corporation

Venting Concerns (Cont'd)

"DOE must recognize that safety must always have priority over efficiency."

"A significant increase in cost will occur for homeowners who vent their existing furnaces and water heaters into a chimney."

Gas Appliance Manufacturers Association

American Council for an Energy-Efficient Economy

"Our information suggests that levels up to 83% are technically feasible without significant risk of corrosive condensation that would threaten conventional furnace and boiler heat exchangers."

Lennox Industries

"The corrosive effects of the condensate, in many cases accompanied by the positive pressure of the combustion products to assure venting, creates a situation in which no proven safe, cost effective, forced air furnaces are manufactured and distributed in commerce."

Background (Cont'd)

- **To address these concerns, it is necessary to understand:**
  - The flue gas condensation phenomenon (how it begins to affect the furnace vent system at higher efficiencies).
  - What technology options exist to mitigate the condensation problem.
- **We reviewed current information on present venting guidelines for installation of furnaces and boilers, including:**
  - National Fuel Gas Code (NFGC)
  - Test data from various organizations
  - Computer simulation models

Background (Cont'd)

- **We conducted a preliminary analysis of**
  – the correlation between steady-state efficiency and AFUE
  – the impact of increased efficiency on the NFGC tables

- **We collected information on technology options to limit concerns about venting.**

Purpose

- **Discuss and obtain feedback on:**
  - Data and results reported by DOE
  - Efficiency limits for non-condensing furnaces and boilers, based on the NFGC and current venting installation practice
  - Effect of higher steady-state efficiency on NFGC tables
  - Technology options

Discussion Items

1. Venting Code Background
2. Difference Between SSE and AFUE
3. Additional Venting Issues
4. NFGC Tables at Higher SSE
5. Technology Options

Next Steps

- **Incorporate comments (due 6/7/02)**
- **Complete pre-ANOPR analyses (7/02-01/03)**
- **Publish**
  - – ANOPR (1/03)
  - – NOPR (2/04)
  - – Final Rule (9/04)

Agenda

1. Venting Code Background
2. Difference Between SSE and AFUE
3. Additional Venting Issues
4. NFGC Tables at Higher SSE
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Venting Code Background

- **Since the 1950s, codes have provided requirements for the installation and operation of gas equipment.**

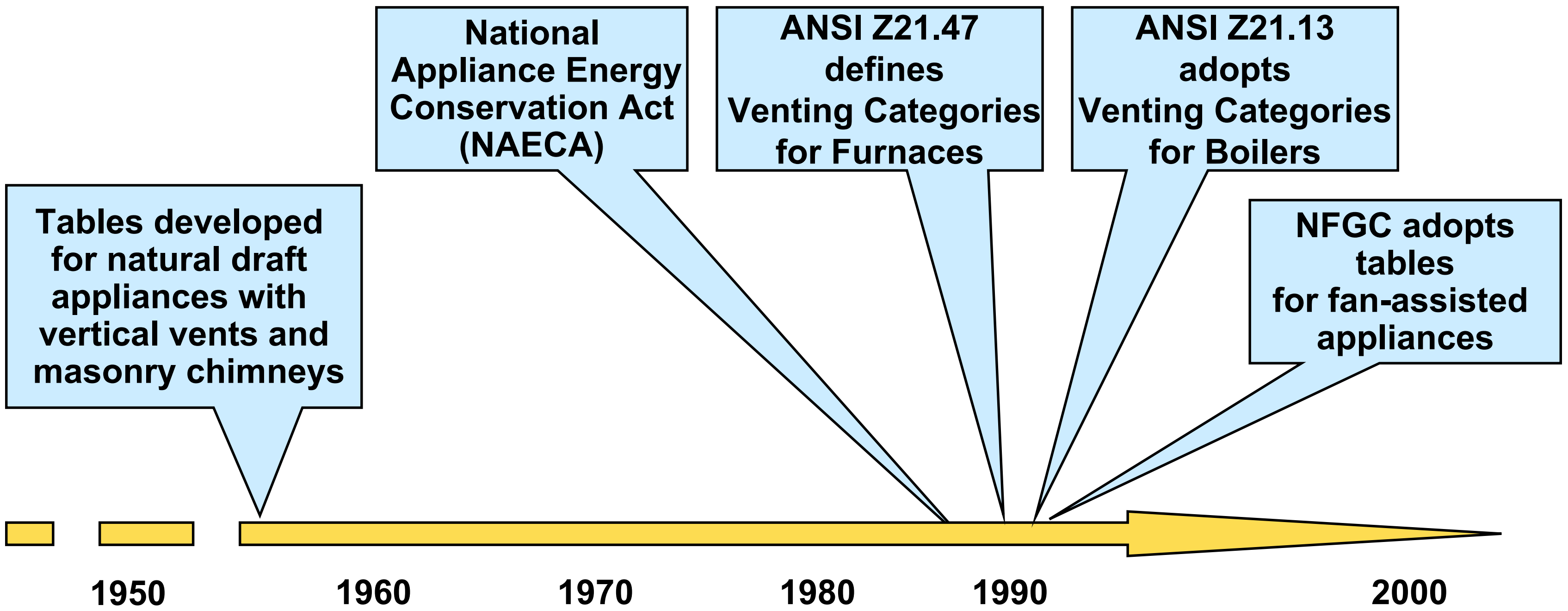
- **We looked at the National Fuel Gas Code – NFGC (NFPA-54/ANSI-Z223.1)**

  “NFGC is a consensus standard and is intended to promote public safety by providing requirements for the safe utilization of gas.”

- **Venting is covered in NFGC**
  - *Chapter 7: Venting of Equipment*
  - *Chapter 10: Sizing of Category I Venting Tables*

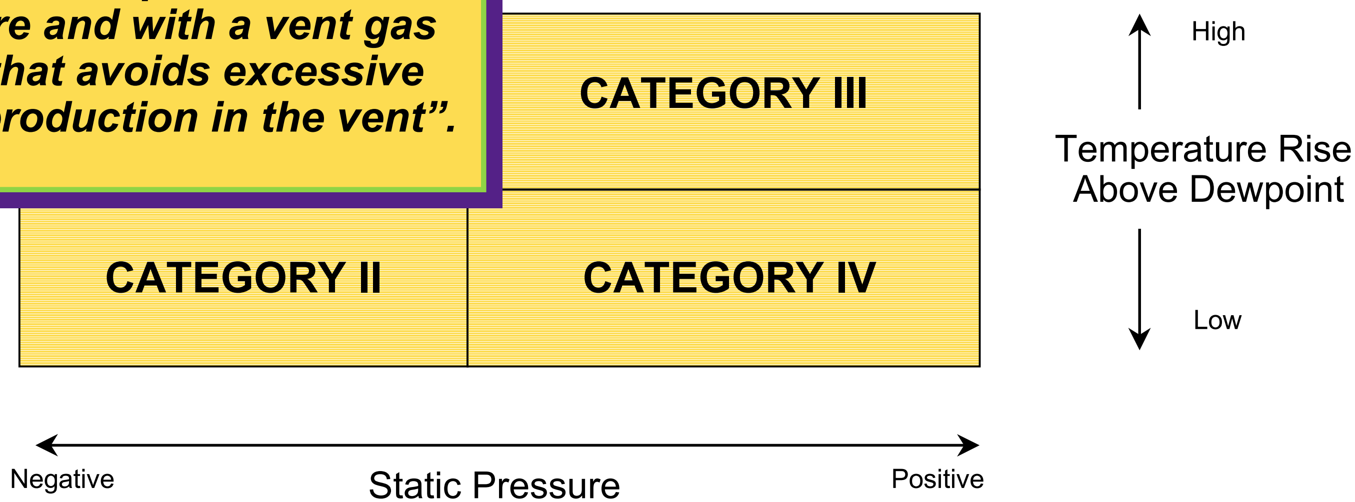
Venting Code Background

NFGC Venting Tables have changed over the years as technology has developed.



ANSI Z21.47 and ANSI Z21.13 define four appliance categories, depending on static pressure in the vent and temperature rise above dewpoint.

CATEGORY I: ***"An appliance that operates with a non-positive vent static pressure and with a vent gas temperature that avoids excessive condensate production in the vent".***



Note: During this workshop we will focus on Category I appliances with emphasis on condensation issues.

The Vent-II computer program was developed and used to generate the NFGC venting tables.

- **History of VENT-II**
  - originally developed in 1983 by Battelle
  - updated (1985-1990) to include new technologies and higher-efficiency furnaces
- **Validation of VENT-II performed by**
  - Battelle - single appliance vent systems
  - AGA Labs - common vent systems
- **Validation of VENT-II for venting systems used with Category I appliances**
  - Type B double-wall vents
  - Standard masonry chimneys

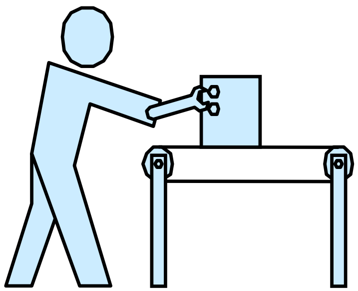
Venting Code Background

Baseline conditions, a set of typical operating parameters and ambient conditions, were established for Category I furnaces.

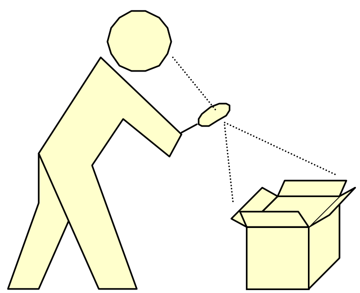
- **Developed After Consultations and Review by the Industry**
- **Included a Steady-State Efficiency Limit of 83%**
- **Venting Tables Generated**
- **Venting Tables Adopted into NFGC**

Venting Code Background

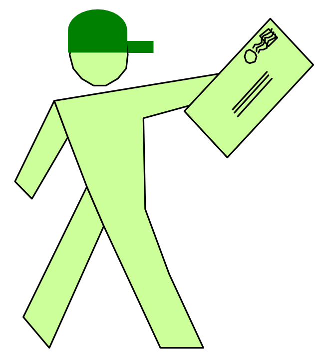
Venting tables are used in every step of the venting system installation.



Some manufacturer’s installation manuals include venting tables.



The installer is required to follow codes and manufacturers instructions for furnaces and boilers.



Typically, the building inspector does not approve the venting system unless it meets the applicable venting code.

Some gas utilities do not turn on the gas unless the venting system meets the applicable venting code.

Agenda

1. Venting Code Background
2. **Difference Between SSE and AFUE**
3. Additional Venting Issues
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Difference Between SSE and AFUE

The difference between Steady State Efficiency (SSE) and Annual Fuel Utilization Efficiency (AFUE) represents the link between the National Fuel Gas Code (based on SSE) and the current Federal Standard (based on AFUE).

Both SSE and AFUE are calculated using the DOE test procedure for residential furnaces (Appendix N, Subpart B, 10 CFR 430):

- *SSE: The difference between 100% and the percentage of heat lost through the flue (both sensible and latent heat for non-condensing furnaces). Electric energy is not included.*

- *AFUE: "The ratio of annual output energy to annual input energy which includes any non-heating-season pilot input loss and does not include electric energy."*

We will now focus on gas-fired non-condensing furnaces, which represent the vast majority of the market. Additional product classes will be discussed in section 5.

Difference Between SSE and AFUE

There are three ways to calculate the difference between SSE and AFUE (SSE-AFUE).

1) From laboratory measurements.

2) From existing directory information.

3) Using a computer simulation model (FURNACE).

Is there any other data source or way to compute SSE-AFUE?

Note that AFUE is readily available (i.e. directories of certified appliances), while SSE is usually not reported.

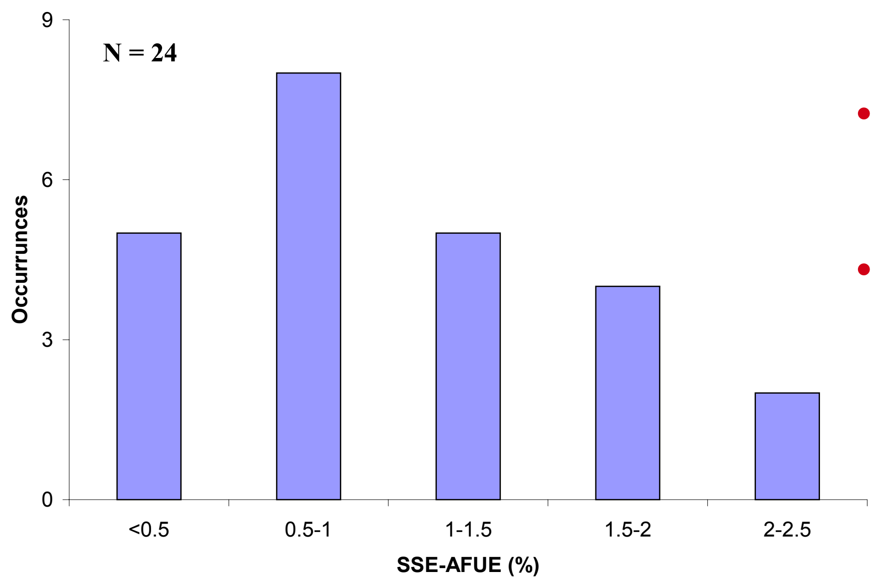
Difference Between SSE and AFUE

1) Laboratory measurements

A number of reported laboratory measurements for non-condensing gas-fired furnaces indicate that:

- SSE-AFUE values range between about 0% and 2.4%

- The average value of this difference is 0.95%



- **Do these values reflect commonly accepted values of SSE-AFUE?**
- **Are there other sources to expand the sample presented on this chart?**

Sources: ITS, ADL, ASHRAE

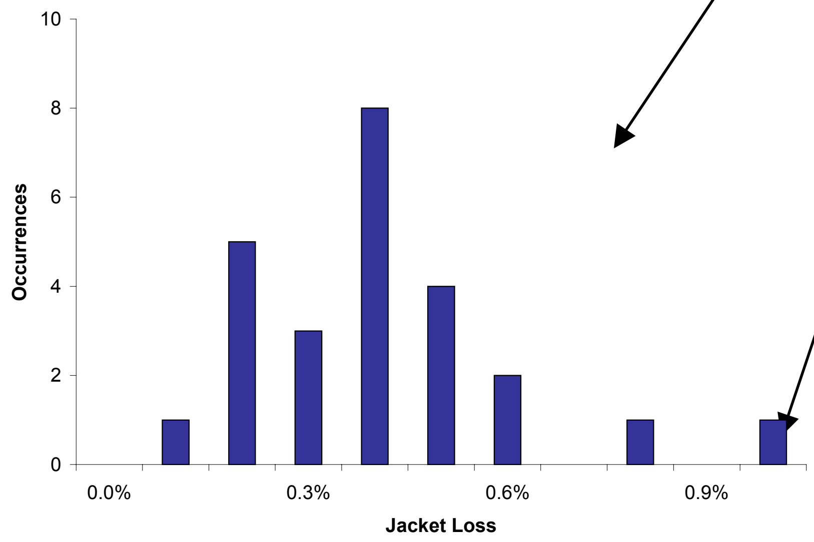
Difference Between SSE and AFUE

2) Directory information (Methodology)

Apply the formula* *SSE-AFUE* = $(100\times Q_{OUT} / Q_{IN}) + (\text{Jacket Losses} \times 1.7) - AFUE$

* Derived from the formula for output capacity in the DOE test procedure

- **Input capacity (Q_{IN}), output capacity (Q_{OUT}) and AFUE values are listed in the directory**
- **Jacket loss values were obtained from laboratory measurements**



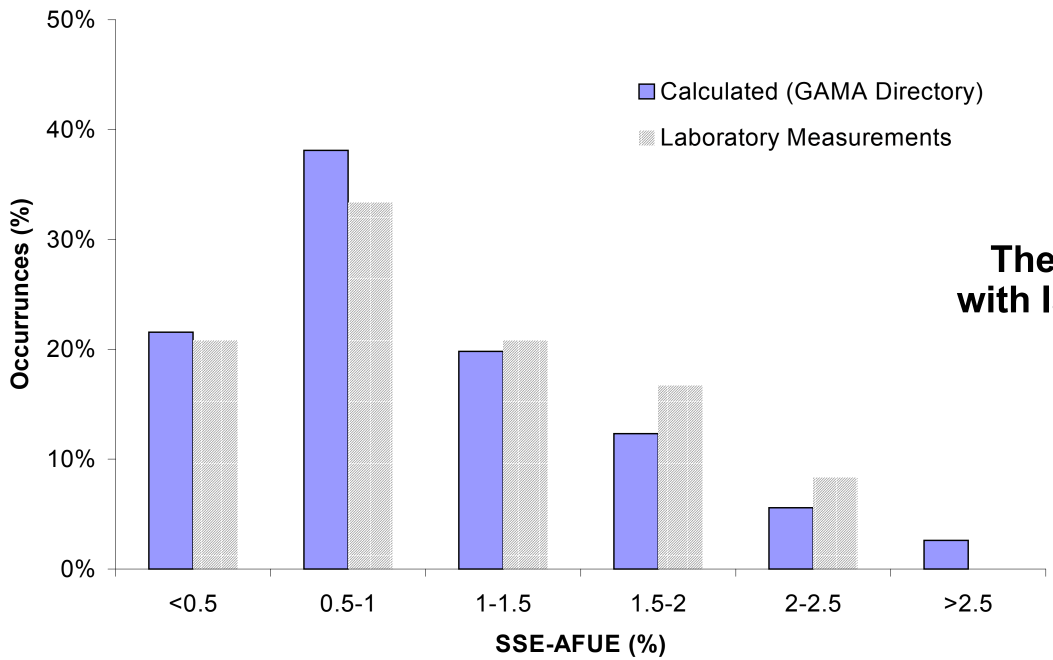
Default jacket loss value, according to DOE test procedure, is 1%

*Sources: ITS, ADL, ASHRAE, GAMA. Non-condensing gas-fired furnaces only.

Difference Between SSE and AFUE

2) Directory information (Results)

SSE-AFUE values calculated from the GAMA directory show a statistical distribution with an average of 0.8%.



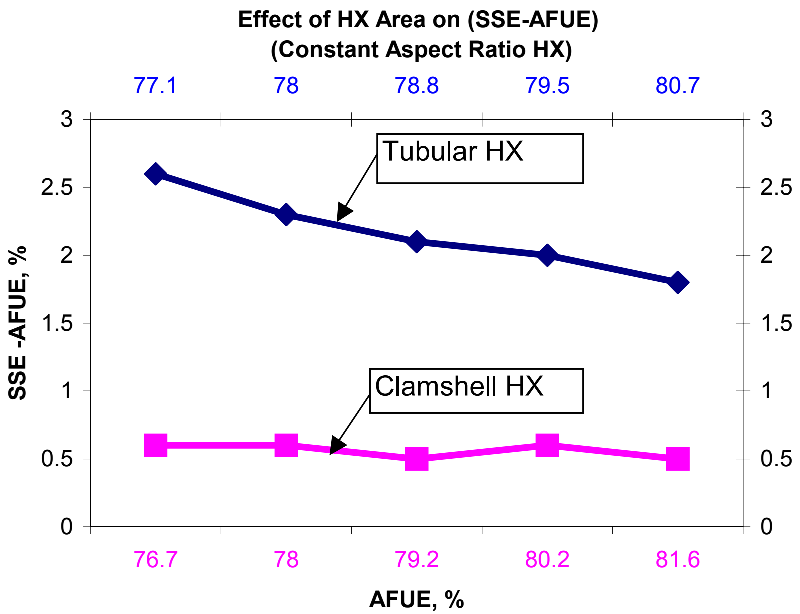
The results are in agreement with laboratory measurements (method #1)

Do these values reflect commonly accepted values of SSE-AFUE?

Note: A similar analysis has been performed on the CEC directory and results are similar.

3) Computer model (FURNACE)

Results indicate that furnaces with tubular heat exchangers have higher SSE-AFUE values and that SSE-AFUE decreases at higher AFUE.



Source: F. Jacob, J. Crisafulli, etc, "Assessment of Technology for Improving the Efficiency of Residential Gas Furnaces and Boiler, Vol.1, GRI-94/0175.2, Sep. 1994

- Do these values reflect commonly accepted values of SSE-AFUE?
- Do this results for tubular HX adequately represent SSE-AFUE based on most current furnace technologies?

Difference Between SSE and AFUE

There are several reasons for the range of calculated SSE-AFUE values, including:

- Variability among the same product series
- Tubular vs. clam shell heat exchanger
- Round-down of AFUE ratings

In the field, additional factors might affect actual SSE-AFUE values:

- Gas heat content
- Air flow
- Room temperature
- Test procedure tolerance

- **Are there additional factors to take into consideration?**
- **Are there any studies which document the impact of the factors affecting SSE-AFUE?**

Agenda

Additional Venting Issues

Common venting (furnace / water heater) systems might be affected by new standard levels.

- **Impact of new water heater efficiency standard level (effective January 2004):**
  - *It might or might not result in a higher Recovery Efficiency (RE).*
  - *A higher RE could raise additional venting concerns.*

- **Possible changes in furnace venting requirements:**
  - *"Orphaned" water heaters would need to be re-vented.*

Are there additional venting concerns or opportunities that apply to common venting systems?

Additional Venting Issues

In addition to non-condensing gas-fired furnaces, other product classes are affected by venting issues.

- Gas-fired boilers

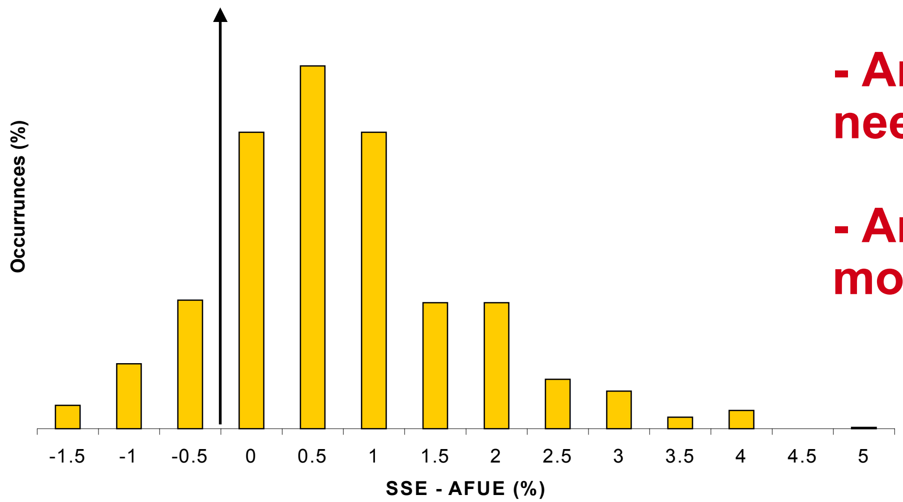
- Mobile home furnaces

- Oil-fired furnaces and boilers

Additional Venting Issues

Gas-fired boilers can reach higher AFUE than non-condensing gas-fired furnaces before venting issues arise.

- **Indoor installation rating**
- **Low return water temperature in the test procedure**
- **Reduced CO concerns**
- **Lower SSE-AFUE than furnaces**



SSE-AFUE calculated using the GAMA directory.

- Are there additional factors that need to be taken into account?

- Are there any boiler simulation models available?

Venting of mobile home furnaces.

- Mobile homes are required to be built in compliance with the Department of Housing and Urban Development's Manufactured Home Construction and Safety Standards (MHCSS).

- MHCSS requires the complete separation of combustion air and interior air, by
  1. Direct vent appliances, or
  2. Installation in enclosures sealed from interior air.

- Are there specific venting concerns or opportunities that apply to mobile home furnaces?
- Are there other codes that apply to this product?

Venting of oil-fired furnaces and boilers.

- **Lower hydrogen content of the fuel**

- **Oil-fired appliances use different venting codes including:**
  - *NFPA 31 – Standard for Installation of Oil-Burning Equipment*
  - *NFPA 211 – Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances*

Are there other specific venting concerns or opportunities that apply to oil-fired furnaces and boilers?

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3	Additional Venting Issues
4	**NFGC Tables at Higher SSE**
5	Technology Options

NFGC Tables at Higher SSE

As steady state efficiency (SSE) increases, the range of available installations is decreased.

Assume 75 kBtu/hr furnace and 4" Diameter Vent.

Reproduction of Table 10.1: Capacity of Type B Double Wall Gas Vents Directly Connected to a Single Appliance

Vent Height	Lateral Length	83% SSE (Current NFGC Table) Min. Cap.	83% SSE (Current NFGC Table) Max. Cap.	85% SSE Min. Cap.	85% SSE Max. Cap.	87% SSE Min. Cap.	87% SSE Max. Cap.
10'	2'	17	118	35	107	NA	NA
	5'	32	113	52	102	NA	NA
	10'	41	104	65	96	NA	NA
20'	2'	14	149	30	139	98	132
	5'	29	143	44	134	NA	NA
	10'	38	133	63	125	NA	NA
	15'	46	124	78	118	NA	NA
	20'	55	116	95	109	NA	NA
50'	2'	11	183	17	173	93	167
	5'	27	177	43	168	122	162
	10'	35	168	55	156	NA	NA
	15'	42	158	68	152	NA	NA
	20'	50	149	84	142	NA	NA
	30'	69	131	122	123	NA	NA

Disclaimer: These tables are provided for discussion purposes only and are not an update of existing NFGC tables.

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5. **Technology Options**

Technology Options

For gas furnaces, possible technology options exist in three different areas to limit concerns about venting.

1 Decrease SSE-AFUE difference

- *Clam-shell heat exchanger*
- *Burner box or damper*
- *Better insulation*

2 Active controls to allow lower tolerances

- **Detection Systems**
  - *Water-activated switches*
  - *CO Detector*

3 Options that allow the vent system to handle SSE's higher than 83%

- **Change appliance operation pattern**
  - *Modulation*
  - *Heat exchanger area control*
  - *Increase excess air*
- **Remove water from the flue**
  - *Expansion-compression device*
  - *Desiccant*
  - *Enthalpy-desiccant wheel*
- **Treat the vent**
  - *Vent coating*
  - *Vent pre-heat*
  - *New materials*
  - *Improved vent connector*
- **Use condensing technology**

Require vent code modification

What technology options should or should not be considered and why?